EVALUATING THE RELATIONSHIP BETWEEN MULE DEER PELLET-GROUP DATA AND AVAILABLE WINTER RANGE, USING LANDSAT IMAGERY

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Abstract.— In this study, mule deer population trend data (deer-days-use/hectare) were statistically analyzed with range area data that were extracted from LANDSAT satellite imagery. The remote sensing techniques developed use multidate, winter images of an area in central Utah. Snow-covered areas and vegetational areas mapped from the imagery were composited into 26 maps representing the approximate winter range available to mule deer on 26 dates over a five-year period (1972–1977). Utah State Division of Wildlife Resources pellet-group transect data were statistically analyzed with range data measured from the satellite imagery. Range area accounted for a fairly large proportion of the variation in deer-days-use/hectare ($r = -.83$). This result seems reasonable since deer population density should increase as available range decreases.

In this study the relationship between vegetational area defined by the extent of snow cover and mule deer pellet-group transect data are examined. LANDSAT satellite imagery was used as a means of measuring the distribution of snow cover and vegetation in an area of central Utah between 1972 and 1977.

Researchers studying deer population dynamics agree that snow cover and winter range are critical limiting factors of deer populations (Aldous 1945, Anderson et al. 1974, Dasmann and Hjersman 1958, Gilbert et al. 1970, Leopold et al. 1951, Levaas 1958, Richens 1967, Wallmo et al. 1977). Use of remote sensing techniques for analyzing wildlife populations and wildlife habitat is not a recent development. Low altitude aerial photograph interpretation has been a commonly employed technique since the mid-1930s for vegetational analysis (Dalke 1937, 1941, Leedy 1948) and for direct censusing of wildlife populations (Heyland 1975, Meier 1975).

In the past 20 years, development of new sensing systems has generated an intense interest among wildlife biologists in the application of new remote sensing techniques. Many standard field procedures used to study wildlife are laborious and time consuming, and the prospect of gaining data more rapidly has prompted much of the current interest in remote sensing. Among the more recently developed sensors that augment conventional aerial photography in wildlife investigations are radar, thermal infrared scanners, and multispectral scanners. Platforms that contain these sensor packages are midaltitude commercial aircraft, high altitude U-2 and RB-57, and NASA's LANDSAT satellites. NASA's LANDSAT program began in the summer of 1972 with the launching of LANDSAT 1 (formerly called ERTS 1) and has continued with the launching of two subsequent satellites (LANDSAT 2 and 3) (U.S. Geological Survey 1979). Because these satellites retrieve data from the same geographic area every 18 days, this new technology provides wildlife managers with the potential of repeated monitoring of wildlife habitat.

In addition to wildlife and vegetation studies, the LANDSAT satellites are a useful data source for numerous other resource studies. One approach important to the present research was initially developed to monitor the variable of winter snow cover in montane hydrologic cycles (Aul and Ffolliott 1975, Barnes 1974, Evans 1974, Meier 1975, Rango 1975). In these LANDSAT snow surveys, visual interpretation of enlarged imagery (scale = 1:250,000) was an accurate means of mapping the areal extent of snow cover. Snow cover and winter range are agreed to be important to deer population dynamics, and it has been demonstrated that LANDSAT is capable of detecting changes in snow cover. With these two factors taken into consideration, this project was undertaken to refine

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a remote sensing technique that would utilize snow measurements made from satellite imagery for predicting regional deer population trends.

STUDY AREA

The study area (Fig. 1), which lies mainly along the Wasatch Plateau in central Utah, is

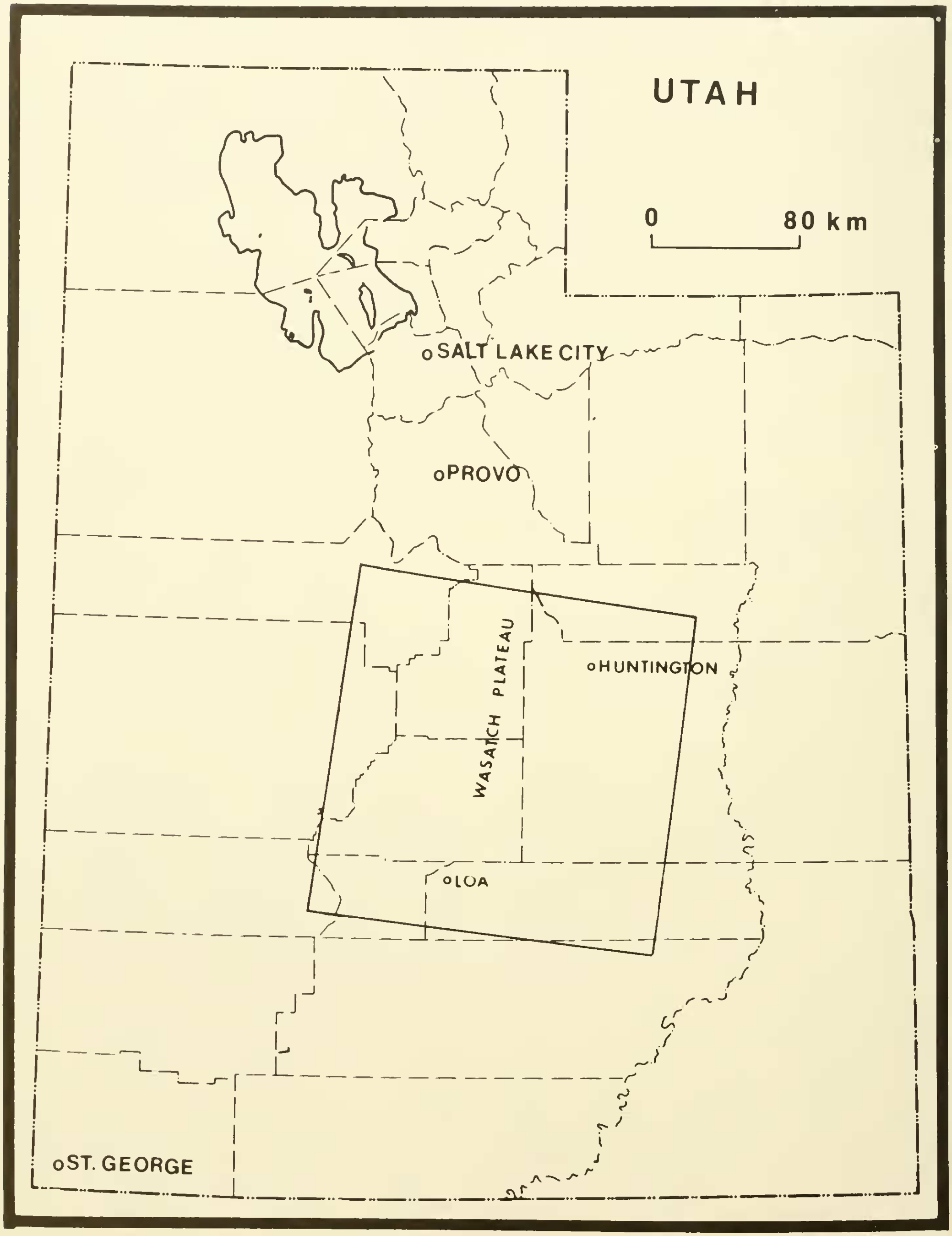

Fig. 1. Location of the study area within Utah. Boundaries are not aligned directly north and south because of the orbital paths of the LANDSAT satellites.

physically complex and consists of dominant, north-south-oriented mountain ranges dissected by low valleys. Physiographic features included in the study area include the Wasatch Plateau, the Sevier Plateau, and the southern tip of the Wasatch Mountains. Vegetation of this area reflects both the complexity of the physical environmental patterns and their apparent modifications by man. Areas modified by man support a combination of agricultural land uses including dry farming (nonirrigated) of winter wheat, irrigated farming of alfalfa, and pasturage of livestock (mainly sheep and cattle). Less disturbed areas of the valleys are dominated by desert shrub species relatively common throughout the cold desert. They include big sage (*Artemisia tridentata*), rabbit brush (*Chrysothamnus nauseosus*), Mormon tea (*Ephedra viridis*), bromegrass (*Bromus* spp.), wheatgrass (*Agropyron* spp.), and grama (*Bouteloua* spp.). Along a hypothetical transect from the low valleys to the mountain crest, the undisturbed vegetation communities above the valley floors form four plant zones that vary according to environmental gradients of temperature and moisture. The first communities to be encountered above the previously described desert shrub communities are either deciduous shrub (*Acer grandidentatum-Quercus gambelii*) or juniper-pinyon (*Juniperus* spp.-*Pinus edulis*). These two communities occur in approximately the same elevational range and are segregated primarily by differences in available moisture, with deciduous shrub communities occurring in the more mesic sites. The second elevational zone comprises a combination of forested plant communities, but the dominant community in the study area is aspen (*Populus tremuloides*). Scattered among this dominant community are relatively homogenous stands of the Douglas fir-white fir community type (*Pseudotsuga menziesii-Abies concolor*); these localized stands are also apparently controlled by local site factors. At higher elevations the communities in the third elevational zone make a gradual transition to spruce-fir (*Picea englemanii-Abies lasiocarpa*). The uppermost community or fourth elevational zone encountered in this transect is alpine tundra (various mat-forming species), which reflects the combination of dessication (frost and wind) and poor soil formation at the highest elevations of this area (Allred 1975, Arnow and Wyckoff 1977, Buchanan and Nebeker 1971). Within the study area (Fig. 1) are 15 deer herd management units, whose boundaries are defined by the Utah State Division of Wildlife Resources (DWR). These herd units (Fig. 2) are the basis for the state's retrieval of deer population data and the implementation of deer management regulations. They are also the areas from which deer population data are analyzed in this study.

METHODS

Data for this study were extracted from two primary sources. The first source was a report published by the Utah State Division of Wildlife Resources (1978) that provided detailed data from pellet-group transects within the study area. The second major data source for this study consisted of imagery from the NASA LANDSAT satellites. Satellite imagery was used for mapping of vegetation distribution and seasonal distribution of snow cover. Vegetation interpretation and mapping was carried out on a false-color composite LANDSAT image at a scale of 1:250,000, dated 25 August 1977 and processed to a positive print. Because of the small scale of the image, detailed vegetation interpretation was not carried out. Instead, the vegetational boundaries mapped consisted of the interface between oak-maple or pinyon-juniper communities and desert shrub communities. This boundary is significant because it approximates the lower elevational limits of vegetation types considered suitable for deer wintering (Leopold 1951, Richens 1967). So, per se, the map discussed was not a map of vegetational species, but rather a map showing the lower elevational extent of all vegetation types considered by many as suitable winter range for mule deer. As this vegetational boundary was interpreted on the image it was traced directly onto an acetate (stable drafting film) overlay. After this map was completed it was photographically reduced to a scale of 1:500,000 (50 percent reduction) and processed to a film positive print. Snow cover was mapped using 70 mm black and white LANDSAT band 5 transparencies (1:3,000,000) and a color additive viewer that enlarged the 70 mm transparencies to a mappable scale (1:500,000). Mapping of snow cover consisted of delineating a boundary along which snow was present on one side and absent on the other. No attempt was made in this study to differentiate snow depths from satellite imagery. Although it is well known that snow depth and snow condition (ice crusts, etc.) both have a strong influence on deer distribution (Gilbert et al. 1970) these parameters were not detectable on the LANDSAT imagery used in this research. The rationale for using simply presence or absence as a measure was that, as snow accumulates and extends to lower elevations or ablates and recedes to higher elevations, the areal extent of snow in itself should represent a general shrinking or enlarging of available winter areas for deer. After the individual images were enlarged into

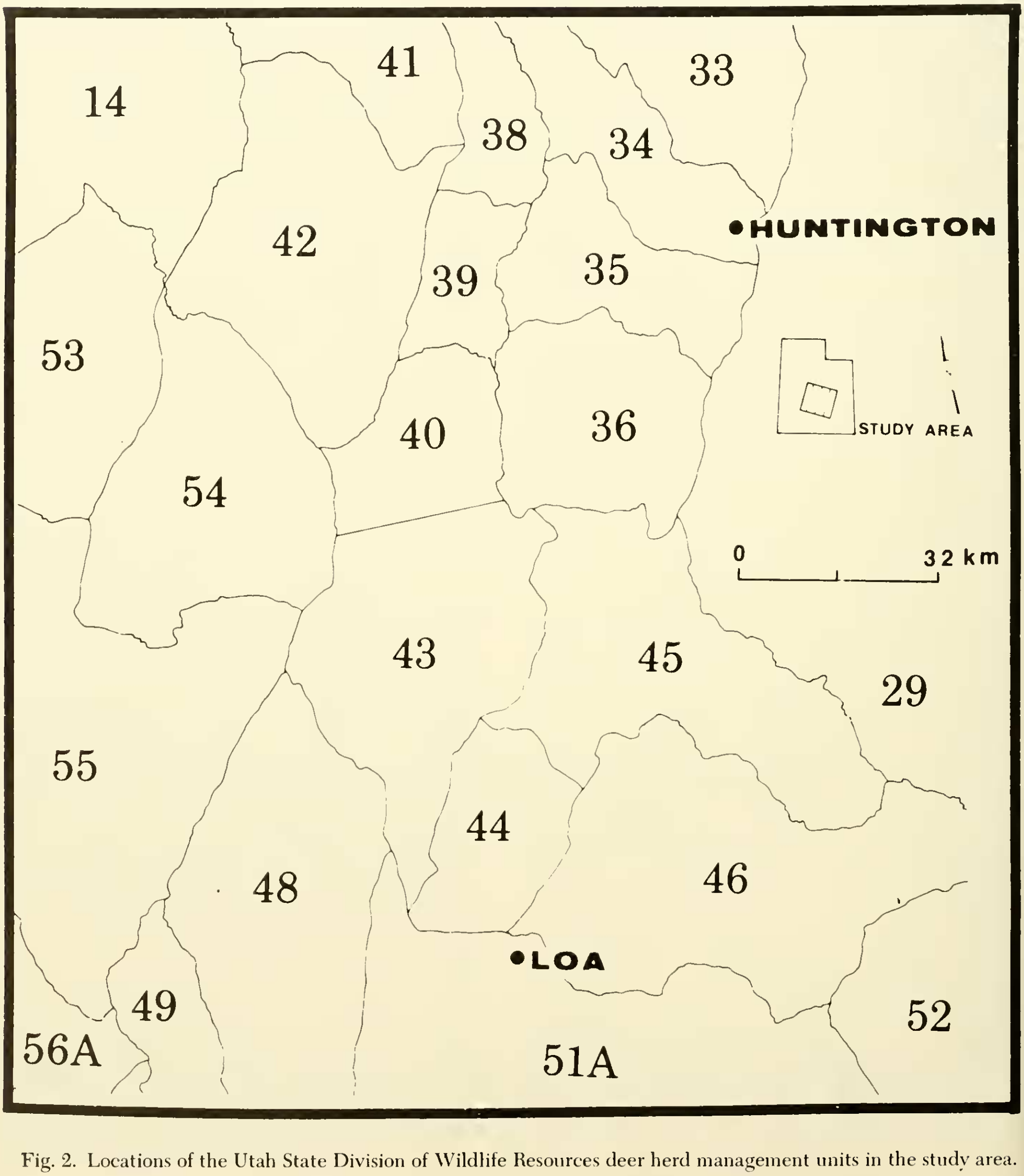

Fig. 2. Locations of the Utah State Division of Wildlife Resources deer herd management units in the study area.

the drafting surface of the color additive viewer, the snow boundary was traced manually onto an acetate overlay. Snow cover was mapped for a period extending from the winter of 1972–73 to the winter of 1976–77. In all, 30 LANDSAT images of different dates were interpreted and mapped for snow cover (Table 1). Although the satellites each cover the same ground scene every 18 days, cloud cover during the winter period limited the acquisition of 18-day repetitive coverage of the study area.

In the last phase of the mapping procedure, the snow cover maps were composited with the vegetation map to form the final maps, which portray the distribution of vegetation assumed to be suitable for deer winter range at given points in time. After the composite maps were produced, the winter range areas were measured with a Hewlett-Packard Model 9866A microcomputer that was interfaced with a map board and cursor. The microcomputer was programmed as an electronic planimeter to automatically compute area from the map scale. As a result of the composite mapping, 26 maps (four images indicated total snow cover and were therefore not mapped) were produced, which illustrate the annual variation, in the mapped winter range, over a five-year period (Fig. 3). Data from both sources were compiled into two separate sets of observations. This compilation was accomplished by dividing the study area into two distinct geographic units (Fig. 4). DWR pellet-group transect data were placed in the observations of the first or second geographic unit and analyzed with vegetational area data from that same area. This summarization of herd unit data from the 15 DWR-designated units was carried out because of a lack of any real barriers to deer migration between most of the DWR units. The boundary that separated the herd units into two distinct geographic units was placed along the center of a broad, low-elevation valley with heavy agricultural use. Because of sparse vegetation this may be a more realistic barrier to deer migration and, therefore, a reasonable separation of populations. After compiling the data in this fashion (Table 2), the vegetational data extracted from satellite imagery and the DWR transect data were analyzed by regression (Nie et al. 1975).

Table 1. Dates of LANDSAT satellite imagery acquired for analysis of snow cover and vegetation.

2 February 1973
15 April 1973
3 May 1973
8 June 1973
30 October 1973
15 February 1974
28 April 1974
16 May 1974
26 June 1974
19 September 1974
25 October 1974
30 November 1974
5 January 1975
28 February 1975
5 April 1975
11 May 1975
25 June 1975
20 October 1975
4 December 1975
18 January 1976
27 January 1976
21 March 1976
30 March 1976
14 May 1976
26 June 1976
5 October 1976
14 October 1976
28 November 1976
16 December 1976
9 April 1977

Results and Discussion

Regression analysis of the data (Fig. 5) supports the assumption of a relationship between range area measured with the remote

Table 2. Data for deer population with observations based on areas corresponding to Figure 4.

Area	Year	Mean deer-days-use/ hectare	Mean square kilometers of winter range
1	1973	61.0	1538.5
	1974	56.2	1834.2
	1975	69.3	2110.3
	1976	40.1	2892.5
	1977	29.7	4133.9
2	1973	128.0	1154.1
	1974	99.0	1533.0
	1975	94.1	1427.6
	1976	72.5	1915.0
	1977	44.6	3014.0

Area 1 corresponds to DWR herd units 34, 35, 36, 45, 46, 51A, 38, 39, 40, 43, and 44.

Area 2 corresponds to DWR herd units 42, 54, 48, 53, and 59.

sensing technique and the DWR pellet-group transect measure of deer-days-use/hectare ($r = -.83$, $P < .003$). These results seem logical, even though in this research there was no direct consideration of the important snow parameters mentioned earlier (i.e., snow depth and snow condition), since it would be expected that seasonal shifts in snow elevation through accumulation and ablation would, perhaps, influence these parameters. The negative relationship demonstrated by these analyses would seem reasonable because, as snow cover increased over the suitable vegetation types, causing a shrinkage of winter

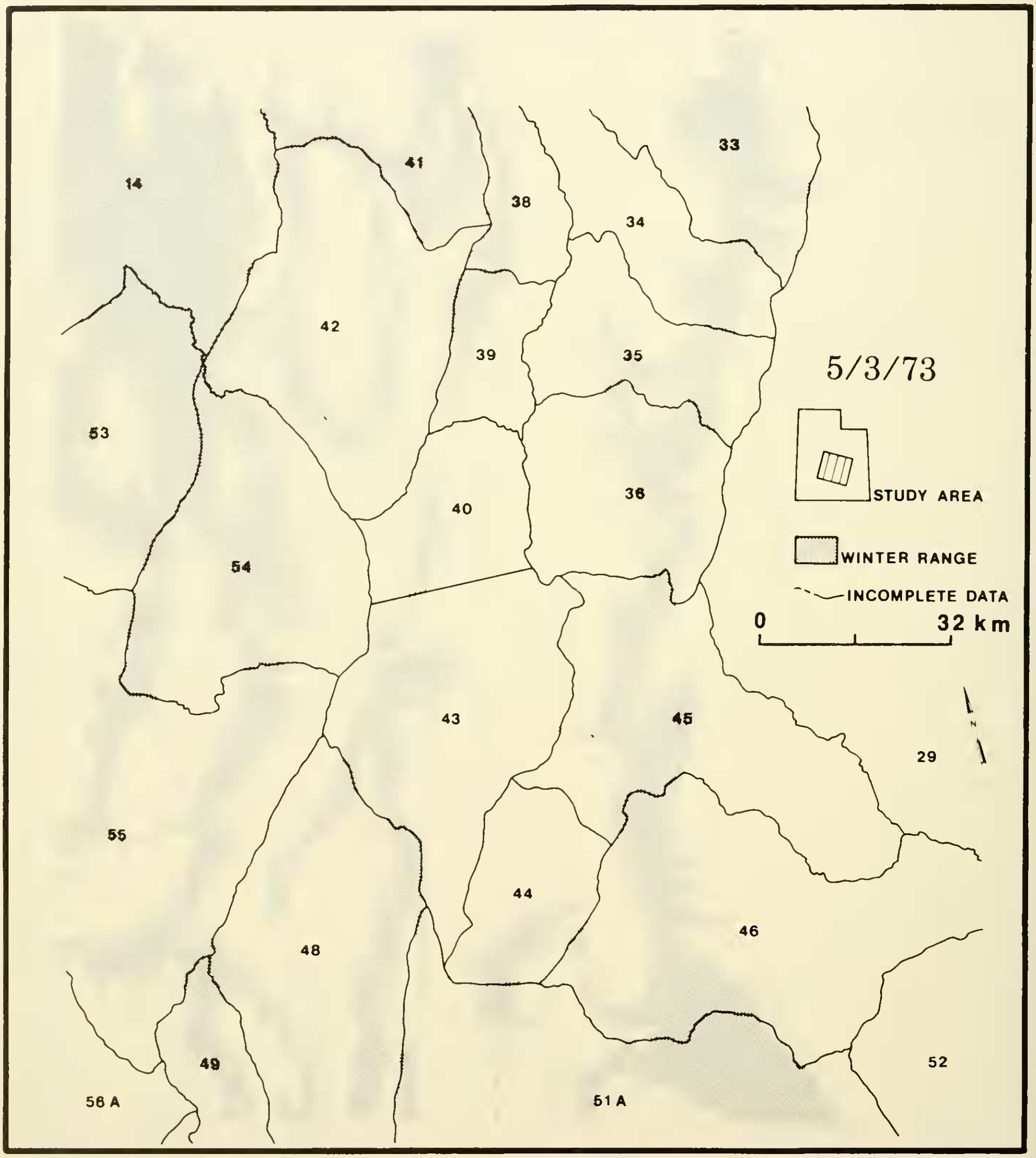

Fig. 3. Sample composite map (1 of 26) that is the result of combining a snow cover map (generated from the interpretation of satellite imagery), a map of the lower boundary of deer habitat (interpreted from satellite imagery), and a map of the state defined herd unit boundaries (delimited by legal description onto a 1:250,000 U.S.G.S. quadrangle). Each of the maps that were developed represent deer winter range available on the date the satellite imagery was acquired.

range, deer use would tend to increase per unit area of available range. This finding may have several important management implications: as a new technique for assessing winter ranges over large areas in a relatively short time, for evaluating land areas for acquisition by the state for winter range preservation, and for analyzing the effects of winter cloud seeding on deer ranges.

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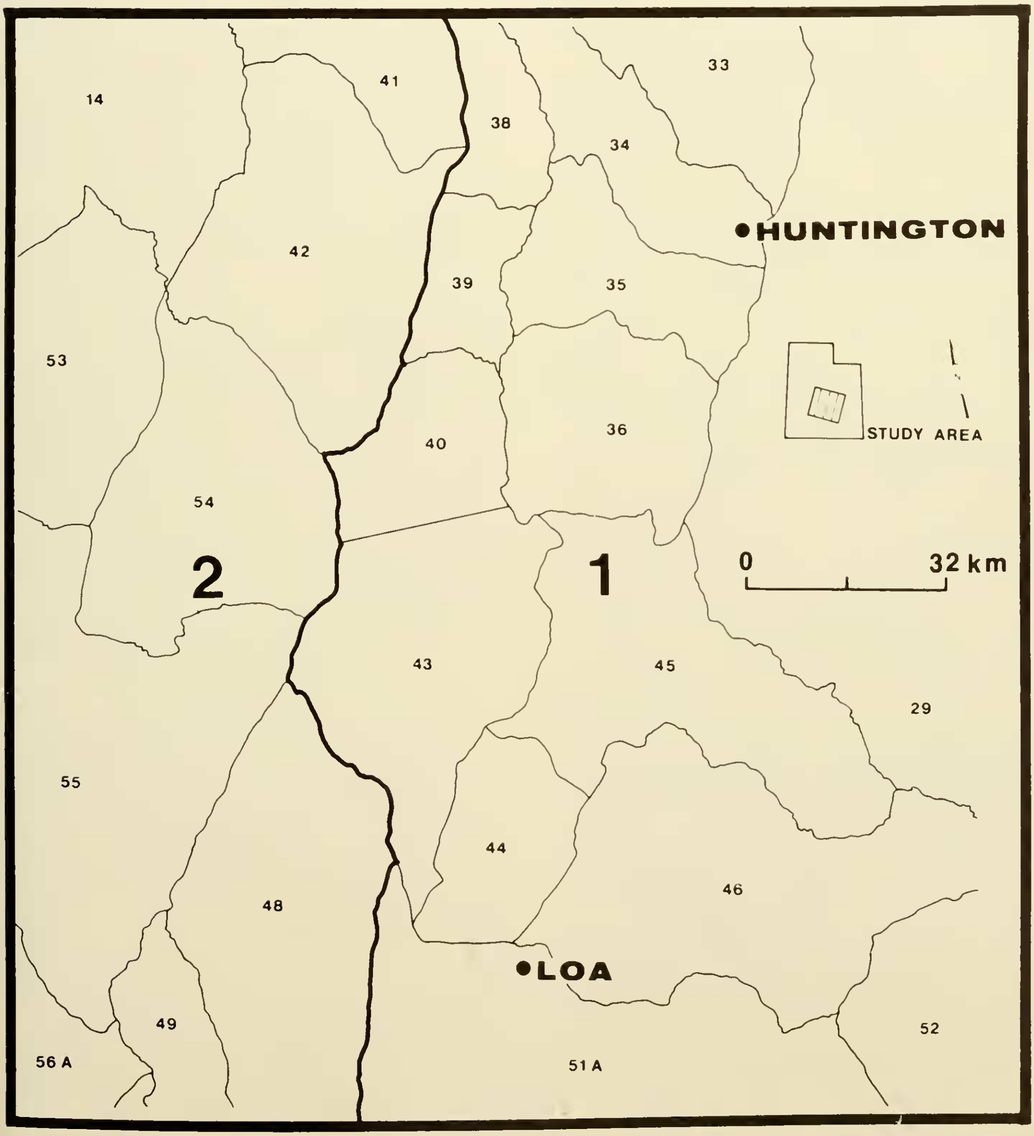
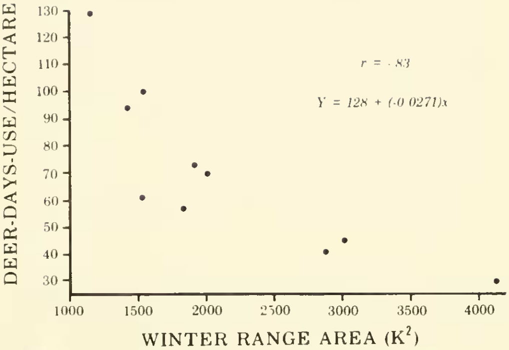


Fig. 4. Study area showing the boundary that was used to divide the herd units into more biologically appropriate samples.



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